COMPARISON OF DISCOVERY RUPES, MERCURY WITH TERRESTRIAL THRUST FAULTS: NEW ESTIMATES OF THE DECREASE IN RADIUS OF THE PLANET DUE TO GLOBAL CONTRACTION.

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The maximum relief of Discovery Rupes is estimated to be ~1.5 km based on a digital elevation model generated by digital stereophotogrametry using Mariner 10 stereo pairs [1]. The horizontal shortening across Discovery, assuming that the height of the scarp is a function of the displacement on the fault, is estimated to be 2 to 6 km over a range in dip of the fault-plane of 25°±10°. Using estimates of the displacement (*D*) and fault length (*L*), indicates that the thrust fault associated with Discovery is consistent with lower values of *D/L* expected for terrestrial faults. This is also the case for other lobate scarps on Mercury. Previous estimates by Strom et al. [2] of the decrease in radius of Mercury due global contraction of 1 to 2 km are based on an average vertical displacement 1 km assuming scarp heights range from 0.5 and 3 km. The results of this study indicate that lobate scrarps have a range in maximum height of about 0.1 to 1.5 km. Thus the decrease in the radius of Mercury resulting from global contraction may be on the order of 1 km or less.

Lobate scarps on Mercury and their counterparts on Mars are thought to result from thrust faulting [2,3,4,5,6,7]. The simplest kinematic model that can be envisioned involves deformation associated with a thrust fault that propagates upwards and breaks the surface. In this case, the amount of horizontal shortening can be estimated by assuming that it is a function of the dip of the fault-plane and the displacement on the fault. Given the elevation of the scarp (*h*) and the fault-plane dip (θ), the displacement (*D*) necessary to restore the topography to a planar surface is given by $D = h/\sin\theta$ and the horizontal shortening (*S*) is given by $S = h/\tan\theta$. The optimum angle θ at which faulting will occur is given by $\tan 2\theta = 1/\mu_s$ where μ_s is defined as the coefficient of internal friction [8]. Laboratory data on the maximum shear stress to initiate sliding for a given normal stress for a variety of rock types are best fit by a maximum coefficient of static friction of 0.6 to 0.9 (best fit μ_s = 0.85)[9]. This suggests that thrust faults will form with dips from about 24° to 30°. Although field measurements of θ for thrust faults typically range between 20° to 25° [8], the large-scale Wind River thrust fault, for example, has a average θ of 35° [10]. Thus it is reasonable to assume that thrust faults associated with lobate scarps will fall within a range in θ of 25°±10°.

Discovery Rupes is the largest lobate scarp that has been observed on Mercury. New measurements of the dimensions of Discovery using digital stereophotogrametry on Mariner 10 stereo pairs indicate that the maximum relief of Discovery is ~1.5 km [1]. The amount of horizontal shortening across Discovery Rupes for a range in θ (25°±10°) is estimated to on the order of 2.1 to 5.6 km (~3.2 km at θ = 25°). Estimates of the horizontal shortening and displacement on the fault associated with Discovery allows a comparison with terrestrial thrust faults. Recent studies based on field observations indicate a positive correlation exists between the maximum displacement on a fault (*D*) and the length of the fault trace (*L*) [11,12,13,14]. This scaling relationship holds for all the fault types (i.e., normal, strike-slip, and thrust) in a wide variety of tectonic settings and a wide range of length scales with values of *D/L* ranging between 10^{-1} and 10^{-3} [11]. The displacement on the fault associated with Discovery Rupes is estimated to be 3.6 km at θ = 25° and length of the fault is on the order 550 km. This is consistent with lower values of *D/L* expected for terrestrial faults (Figure 1).

The distributed nature and generally random orientations of the thrust faults on Mercury [2,3,4] indicates that compressional stresses were widely distributed and horizontally isotropic. This is consistent with compressional stresses resulting from global contraction. Strom et al. [2] suggested that lobate scarps reflect global contraction that resulted in a significant decrease in Mercury's radius. Assuming an average vertical displacement of 1 km based on estimates of scarp heights ranging from 0.5 and 3 km and fault-plane dips of 45° and 25°, they estimated a decrease in the radius of planet of 1 to 2 km. New measurements based on digital stereophotogrametry for Discovery Rupes and photoclinometry on other lobate scarps indicate a range in maximum height of about 0.1 to 1.5 km. A more accurate average of maximum height for moderate and large-scale scarps is 500 m. Using estimates of the total length of scarps of 15,150 km from Strom et al. [2] mapped over ~ 23.8% of the surface, the decrease in surface area is estimated to be ~1.5×10^4 km^2 assuming a fault-plane dip 25°. This represents a decrease in the radius of the planet of ~1 km. If the average fault-plane dip is >25°, the decrease in radius falls below 1 km. In order for the radius decrease to approach 2 km, the average fault-plane dip would have to be below 15°. Thus the decrease in the radius of Mercury due to global contraction is estimated to be on the order of 1 km or less.

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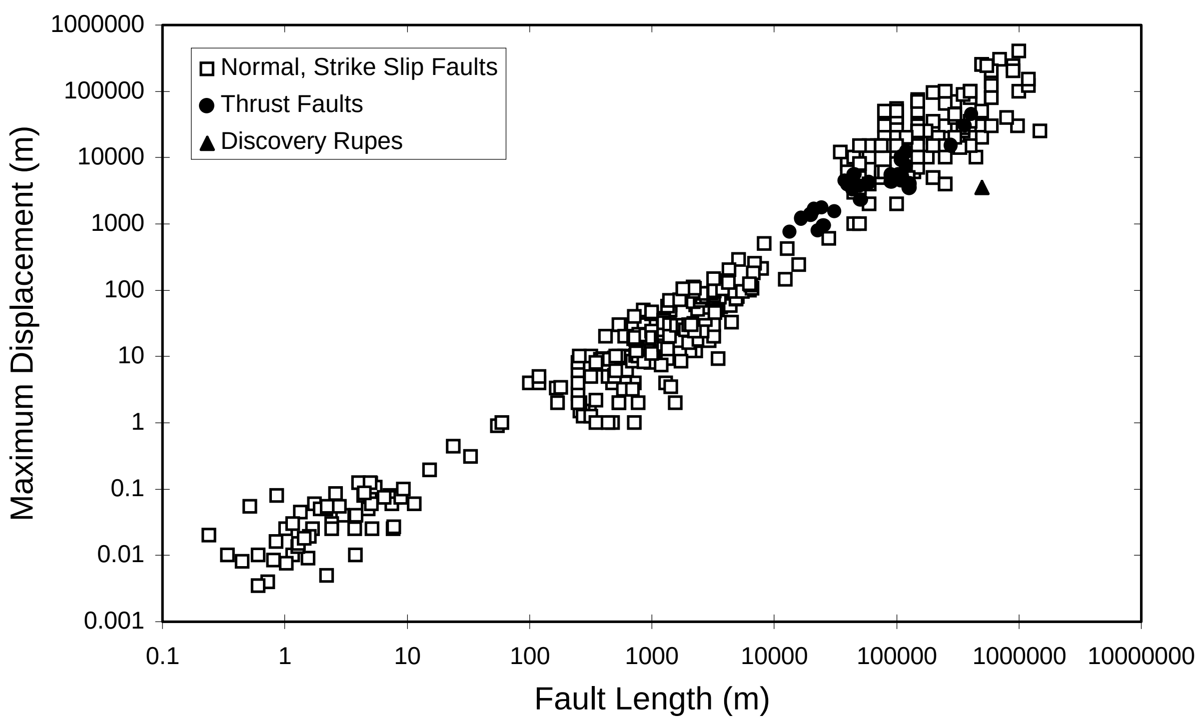

Figure 1. Log-log plot of maximum displacement Vs fault length for terrestrial faults and fault associated with Discovery Rupes. The data for terrestrial faults is from nine different data sets (includes data for 29 thrust faults) [see 11].